WHAT IS CLAIMED IS:

1.   A method for determining an overlay error between at least two layers in a multiple layer sample, the method comprising:

5   using an imaging optical system to measure a plurality of measured optical signals from a plurality of periodic targets on the sample, wherein the targets each have a first structure in a first layer and a second structure in a second layer, wherein there are predefined offsets between the first and second structures; and

using a scatterometry overlay technique to analyze the measured optical signals of the periodic targets and the predefined offsets of the first and second structures of the

10   periodic targets to thereby determine an overlay error between the first and second structures of the periodic targets.

2.   A method as recited in claim 1, wherein the imaging optical system is configured to have an illumination and/or collection numerical aperture (NA) and/or spectral band selected so that only a 0th diffraction order is collected and measured for the plurality of

15   measured optical signals.

3.   A method as recited in claim 2, wherein the illumination NA of the imaging optical system equals the collection NA, an incident beam of the imaging optical system is normal to a surface of the sample, and the imaging optical system is configured to meet the following condition:

20    $n\lambda = d(NA_i + NA_c)$

wherein n equals 1, λ is the wavelength, d is a pitch of the target's structures, NA_i is the illumination numerical aperture, and NA_c is the collection numerical aperture.

4. A method as recited in claim 2, wherein the illumination NA of the imaging optical system equals the collection NA, an incident beam of the imaging optical system is normal to a surface of the sample, and the imaging optical system is configured to meet the following condition:

$$n\lambda \gtrless 2dNA(1+\epsilon)$$

wherein n equals 1, λ is the wavelength, d is a pitch of the target's structures, NA is the numerical aperture of the imaging optical system, and is ϵ an approximation factor for structures of the periodic targets which are not infinitely periodic.

5. A method as recited in claim 4, wherein ϵ is about less than 0.5.

6. A method as recited in claim 2, wherein the spectral band of the imaging optical is selected by adjusting a wavelength selection device or the wavelength modulation device.

7. A method as recited in claim 6, wherein the wavelength selection device is from a group consisting of a set of band pass interference filters, a set of continuously varying bandpass interferencde filters, a set of grating based spectrometers, a set of Fourier transform interferometers, and a set of acousto-optic tunable filters and the wavelength modulation device is controlled by changing one or more optical path lengths therein.

8.   A method as recited in claim 6, wherein the wavelength selection device or the wavelength modulation device is positioned within the imaging optical system's illumination path.

9.   A method as recited in claim 6, wherein the wavelength selection device or the wavelength modulation device is positioned within the imaging optical system's collection path.

10.   A method as recited in claim 6, wherein the imaging optical system further includes a polarizer in the illumination path and an analyzer in the collection path.

11.   A method as recited in claim 2, wherein the analysis of the measured optical signals includes deriving spectral information from the measured optical signals using a transform, such as a Fourier or a Hadamard transform.

12.   A method as recited in claim 2, wherein the measured optical signals are in the form of one or more image(s).

13.   A method as recited in claim 12, wherein the one or more images include center portions of each target and the image center portion of each target is analyzed.

14.   A method as recited in claim 2, wherein the overlay error is determined without comparing any of the measured optical signals to a known or reference signal from a sample target having a known overlay error.

15.   A method as recited in claim 2, wherein each first structure has a first center of symmetry and each second structure has a second center of symmetry and wherein the

first center of symmetry and the second center of symmetry for each target are offset with respect to each other by a selected one of the predefined offsets.

16. A method as recited in claim 2, wherein the overlay error is determined without comparing the measured optical signals to calibration data.

17. A method as recited in claim 2, wherein the scatterometry overlay technique is a linear based technique.

18. A method as recited in claim 2, wherein the scatterometry overlay technique is a phase based technique.

19. A method as recited in claim 1, wherein the imaging optical system has a broadband source for generating an optical incident beam having multiple wavelengths, a detector for detecting a measured signal from the sample in response to the incident beam and a filter for selectively passing particular one or more wavelengths of the output signal to the detector, wherein using the imaging optical system includes directing at least one radiation beam towards each target to measure a plurality of measured signals from the periodic targets while adjusting the filter so as to pass a particular one or more wavelengths of the measured signals through the filter towards the detector in the form of a plurality filtered signals.

20. A method as recited in claim 19, wherein the analysis of the filtered signals and the predefined offsets includes obtaining an intensity from some or all of the pixels of an image of each target and combining the intensities of each target together to give an intensity value for each target at a particular setting of the filter.

21.   A method as recited in claim 20, wherein the analysis of the filtered signals and the predefined offsets further includes determining a linear dependence of the overlay error based on the intensity values for each target and determining the overlay error based on such linear dependence.

22.   A method as recited in claim 20, wherein the analysis of the filtered signals and the predefined offsets further includes determining a periodic function of the overlay error based on the intensity values for each target and determining the overlay error based on such periodic function.

23.   A method as recited in claim 20, wherein the filter is adjusted so as to give a maximum difference between the target's intensity values.

24.   A method as recited in claim 19, further comprising repeating operations (a) and (b) over multiple wavelengths, wherein the measured optical signals having the largest contrast are used to determine overlay error.

25.   A method as recited in claim 19, further comprising repeating operations (a) and (b) over multiple wavelengths, wherein a weighted average of the measured optical signals is used to determine overlay error.

26.   A method as recited in claim 20, further comprising analyzing the image of the periodic targets to detect any processing problems other than those caused by overlay error.

27.   A method as recited in claim 26, wherein the processing problems are selected from a group consisting of (i) a use of an incorrect reticle to form the sample, (ii) an

incorrect resist thickness, (iii) resist streaking, and (iv) a chemical mechanical polishing problem.

28.   A method as recited in claim 20, further comprising acquiring the image of at least two of the periodic targets simultaneously.

29.   A method as recited in claim 19, wherein each first structure has a first center of symmetry and each second structure has a second center of symmetry and wherein the first center of symmetry and the second center of symmetry for each target are offset with respect to each other by a selected one of the predefined offsets.

30.   A method as recited in claim 19, wherein the overlay error is determined without comparing the measured optical signals to calibration data.

31.   A method as recited in claim 19, wherein the scatterometry overlay technique is a linear based technique.

32.   A method as recited in claim 19, wherein the scatterometry overlay technique is a phase based technique.

33.   A method as recited in claim 1, wherein the imaging optical system comprises a spatial filter for selectively filtering the optical signal measured from the sample to thereby measure the optical signal from each of the periodic targets while spatially filtering at least a portion of at least one of the measured optical signals.

34.   A method as recited in claim 33, wherein each first structure has a first center of symmetry and each second structure has a second center of symmetry and wherein the

first center of symmetry and the second center of symmetry for each target are offset with respect to each other by a selected one of the predefined offsets.

35.   A method as recited in claim 33, wherein the overlay error is determined without comparing the measured optical signals to calibration data.

36.   A method as recited in claim 33, wherein the scatterometry overlay technique is a linear based technique.

37.   A method as recited in claim 33, wherein the scatterometry overlay technique is a phase based technique.

38.   A method as recited in claim 1, wherein the measured optical signals are each in the form of a line image.

39.   A method as recited in claim 38, wherein each first structure has a first center of symmetry and each second structure has a second center of symmetry and wherein the first center of symmetry and the second center of symmetry for each target are offset with respect to each other by a selected one of the predefined offsets.

40.   A method as recited in claim 38, wherein the overlay error is determined without comparing the measured optical signals to calibration data.

41.   A method as recited in claim 38, wherein the scatterometry overlay technique is a linear based technique.

42.   A method as recited in claim 38, wherein the scatterometry overlay technique is a phase based technique.